PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Process of Removing Gas from Coal and other Carbonaceous Materials in Situ

I, Leo Ranney, of Petrolia, Ontario, Canada, a citizen of the United States of America, do hereby declare the nature of this invention to be as follows:—

This invention relates to improvements in the process of removing gas from coal and other carbonaceous material in situ.

The primary object of this invention is to provide a method for the removal of gas from an area in a coal seam or other porous bed prior to the extending of mining operations to that area.

A further object of this invention is to provide a method for accelerating the exudation and recovery of gas from coal seams. Still further objects of the invention are to remove one of the ever present hazards of coal mining, that is, the collection of combustible gases in the workings, and to make available for use, what is now a waste product of the industry and to prevent the flow of gas from unworked areas or from gas bearing strata adjacent thereto, into the workings of coal mines, and thereby to reduce the cost of mine ventilation.

Heretofore it has been proposed to remove mineral oil and gases from bituminous and gaseous deposits with the aid of movable air dams, and by the drilling of bore holes into that part of the oil bearing deposits blocked off by the movable air dam. Such a method may be applicable to the removal of oil and gas from loosely consolidated deposits, such as oil sand and gravel, but is entirely impracticable in connection with the degasification of solid or highly consolidated gas bearing deposits, such as coal seams and shale, principally due to the fact that it does not provide adequate means to prevent the infiltration of air, nor does it expose sufficient surface areas for the exudation of gas.

A considerable part of the gas exuded by coal when pressure is released and it is exposed to the air, exists in the coal as free gas, whether laid down as such with the coal, or later absorbed by it from outside sources or formed within the coal by chemical processes. Before pressure is released part of this free gas lies in the fissures extending through the coal, but a much greater part is absorbed within the coal itself in pores often of molecular size, under pressures sometimes as high as several thousand pounds per square inch. These minute pores are connected with each other and the system so connected is in a way a network of small capillaries.

This occluded or absorbed gas is driven off gradually during mining operations, so that it is a continuing hazard to workmen and a handicap to mine ventilation, and the loss of it is a waste of a natural resource.

In some coals a quantity of gas is formed by chemical changes after a part of the rock pressure on the coal has been released. This formed gas, as well as the originally occluded or absorbed gas, in order to escape from the coal, must also pass out through the capillary system to and through the fissures in the coal.

In coals of certain structures, the exudation of gas from the pores and capillaries, is at a relatively high rate, without stimulation by artificial means. In other structures, I have found that the exudation of the gas from the pores and capillaries of the coal is at a relatively low rate, but that same may be greatly hastened by slightly raising the temperature of the coal, likewise an increase in temperature hastens any gas forming chemical action that may be taking place within the coal, thus when the natural exudation of gas from the pores and capillaries is slow an increase in temperature has a doubly beneficial effect. The gas held within the pores and in the capillary system tends to expand and drive itself out of the pores even with a slight increase in temperature. In some cases an increase of ten degrees (F.) may be expected to almost double the rate of gas exudation. The application of heat also reduces the viscosity of the gas.

My process comprises the removal of gas from any area in a coal seam or other porous bed, previous to the com-

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mencement of mining operations in that area, or in the removal of gas coincidental with the extending of the workings of the mine and when necessary, the stimulating and accelerating of the formation and exudation of gas by coal, by raising the temperature of the coal and applying pressure to the gas within the coal.

With the foregoing objects outlined and with other objects in view, which will appear as the description proceeds, the invention consists of the novel features hereinafter described in detail.

When it is intended to remove the gas from coal areas, which exude gas at a relatively high rate, I drive a tunnel into, or adjacent to the coal seam comprising the area to be degasified, leaving sufficient coal or rock pillars for support of the roof. This tunnel during the course of construction may, if necessary be ventilated by any usual means, such as a brattice and blower.

Having constructed the tunnel of any desired length, I then exend from the tunnel, into the coal area to be degasified, sapping tunnels which may be from two hundred and fifty to two thousand feet or more in length, depending upon the area to be degasified, and which may be of a size capable of use as haulage ways, when mining operations are to be commenced after removal of gas from the coal. The first sapping tunnel of the system should be located a sufficient distance from the old workings to prevent the infiltration of air therefrom into the gas removal system. In particularly gaseous areas it may be found advantageous to temporarily seal the sapping drifts at their entrance into the tunnel to prevent loss of gas and simplify the ventilation of the tunnel.

It may be found desirable in certain instances, to increase the exposed surface of the coal to be degasified by making borings from the sapping tunnels into the coal seam, and in some instances, particularly where subsequent mining of the coal is not intended, to place explosive charges in the bore holes and to shoot them for the purpose of breaking up the coal seams and exposing larger surfaces. Ordinarily it is better practice to shoot the explosive charges after completion of the gas removal system, but prior to completing sealing same.

Having completed the sapping tunnels and such borings as may be desirable, I then construct, preferably of concrete poured under pressure, one or more barriers in the open-end of the tunnel nearest the old workings of the mine or the shaft as the case may be. A pipe is extended from the shaft or from the old workings through the barriers into the tunnel and is connected through a suitable pipe to exhaust pumps and gas reservoirs located on the surface of the ground.

I have found that the installation of barriers of concrete and other substantially impervious material is not always sufficient to prevent the infiltration of air around the barriers when a partial vacuum is placed on the gas removal system. In cases where the coal seam consists of a relatively impervious mass, the infiltration of air around the barriers may be prevented by coating the surface of the coal in the tunnel between the barriers with a substantially impervious coating, such as concrete and/or asphalt paint, also by extending the substantially impervious concrete or asphalt paint coating along the surface of the coal at the end of the tunnel connected with the shaft or old workings of the mine and in some cases along the face of the coal in the old workings nearest to the sapping or gas removal system.

However, in some instances it will be found that a coating of such material as concrete or asphalt paint will not be sufficient to prevent the infiltration of air. In such instances, I propose to use two or more barriers at the end of the tunnel and to fill the tunnel between the barriers with a mixture of mud and crude oil or some other plastic material and in some cases to maintain it under pressure. Upon placing the gas removal system under a vacuum, the mud or other plastic material will flow into the seams and crevices of the coal face adjacent to the walls of the tunnel and effectively seal the gas removal system against the infiltration of air.

Having completed the gas removal system and sealed the tunnel against the infiltration of air, the gas removal system, provided the gas pressure is not sufficient to deliver the gas to the storage reservoirs, is placed under partial vacuum, and the gas exhausted through a pipe and delivered to the surface of the ground.

It may be found necessary to discard some of the first gas withdrawn from the gas removal system, as it may be diluted with air and of small commercial value. As soon as the air content of the gas becomes sufficiently low, the gas exhausted from the workings may be conducted to any suitable reservoir for future use.

In certain formations, it is advantageous to drive a tunnel below the coal

seam to be degasified and to drive sapping drifts or bore holes from the tunnel into the coal seam to be degasified. After such gas removal system is completed the sealing operation is as hereinbefore described.

In some instances, it will be found that gas is not only occluded in coal seams, but in the rock roof and floor rock above and below the seams. In such cases it will be necessary to provide means not only for the removal of the occluded gas from the coal seams, but for the removal of the interstitial gas from the roof and floor rock. In such cases, I drill bore holes from the sapping tunnels beyond the coal seam into the roof and floor rock adjacent thereto and if the floor and roof rock are not sufficiently porous to permit the relatively easy flow of gas into the bore holes, I place explosive charges therein, and then explode them to cause a fracture in the rock and thus expose additional area for the flow of gas therefrom. The gas is then exhausted as herein previously described.

In carbonaceous formations where the natural exudation of gas is relatively slow, I first construct a gas recovery system similar to one of the types herein above described.

Having completed the gas recovery system, I construct a second tunnel system, consisting of a tunnel with connecting sapping drifts, which are located substantially parallel to and between the sapping drifts of the gas recovery system, which second system is then sealed in the manner hereinbefore described, pipes being arranged for connection of the tunnel system with a source of heated gas, and means for placing the heated gas under pressure. This second tunnel system may be designated as a warm gas pressure system.

Having completed the gas recovery system and the warm gas pressure system above described, I proceed as follows: Heated natural or manufactured gas is pumped under pressure through pipes into the tunnel and connecting tunnels of the warm gas pressure system. This gas is then driven into the fissures exposed at the coal face and passes along these fissures through the coal toward the parallel gas recovery sapping drifts, heating the coal in the area between the adjacent sapping drifts to any desired degree depending upon the initial temperature and pressure of the gas introduced.

When the temperature of the coal composing the walls of the pressure tunnels and sapping drifts has been increased ten degrees (F.) or more and this increased temperature has extended well back into the coal face or tunnel wall, the temperature of the injected gas may be reduced to allow such injected gas to take up the heat of the coal near the walls of the pressure tunnels and carry this heat into the coal nearer the gas recovery tunnel and sapping drifts.

While the operations are being carried on the gas recovery system may, if gas is not being produced therein at pressures sufficient to deliver it to storage reservoirs on the surface of the ground, be placed under partial vacuum and the gas exhausted in the manner hereinbefore described.

In cases where the gas is delivered from the recovery system at relatively high temperatures, it may be desirable to use a part thereof for reinjection into the warm gas pressure system. This may be accomplished by passing a part of the gas through a compressor (saving the heat of compression) then through a heating chamber or coil to further raise the temperature and into the warm gas pressure system through pipes.

The exudation and recovery of gas is controlled by the temperature and pressure of the gas injected. The higher the temperature and pressure, the more rapid the extraction.

When the body of the coal under treatment has been sufficiently heated and a sufficient percentage of occluded gas effected, the injection of heated gas may be discontinued, and if desirable the pressure tunnels and sapping drifts may be converted into a gas recovery system while the coal is still warm, the gas being exhausted through pipes initially provided for the introduction of heated gas. In this way gas may be withdrawn simultaneously from all sides of the coal body under treatment.

In cases where the coal is quite porous, I may substitute wells drilled from the surface of the ground, for one or both of the tunnel systems sealing the wells from the infiltration of atmospheric air, the same as when tunnel systems are used. In this modification of my process, I inject the warm gas through one system of wells, and recover gas either through a sapping drift system or the other system of wells.

When wells for gas extraction or warm gas injected are used, I prefer to drill same from the surface to and through the coal seam, and to explode explosive charges in the wells opposite the exposed coal face therein to fracture the coal and to facilitate the extraction

or injection of gas, as the case may be.

In the operation of either system, it is desirable to recover the gas from the coal before the coal has time to cool off, as coal absorbs some gas, particularly when it is cold.

If the coal is heated and allowed to cool again without any gas being removed in the meanwhile, the coal when cool will contain its original gas, but if while the coal is warm, substantially all recoverable gas is extracted from it, then when the coal cools again, it will be substantially non-gaseous in subsequent mining operations.

From the above description, it is believed that those skilled in the art will clearly understand the present invention, and it is manifest that changes may be made in the details disclosed without departing from the spirit of the invention.

Dated the 7th day of September, 1934.

LEO RANNEY.

COMPLETE SPECIFICATION

Process of Removing Gas from Coal and other Carbonaceous Materials in Situ

I, Leo Ranney, a citizen of the United States of America, of Petrolia, Ontario, Dominion if Canada, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to an improved process of obtaining naturally occurring gas from coal and other gas bearing formations.

The primary object of this invention is to provide a method for the removal of gas from an area in a coal seam or other porous bed prior to the extending of mining operations to that area or solely for the gas value.

A further object of this invention is to provide a method for accelerating the exudation and recovery of gas from coal seams. Still further objects of the invention are to remove one of the ever present hazards of coal mining, that is, the collection of combustible gases in the workings, and to make avalaible for use, what is now a waste product of the industry and to prevent the flow of gas from unworked areas or from gas bearing strata adjacent thereto, into the workings of coal mines, and thereby to reduce the cost of mine ventilation.

Heretofore it has been proposed to remove mineral oil and gases from bituminous and gaseous deposits with the aid of movable air dams, and by the drilling of bore holes into that part of the oil bearing deposits blocked off by the movable air dam. Such a method may be applicable to the removal of oil and gas from loosely consolidated deposits, such as oil sand and gravel, but is entirely impracticable in connection with the removal of gas from solid or highly consolidated gas bearing deposits, such as coal seams and shale, principally due to the fact that it does not provide adequate means to prevent the infiltration of air, nor does it expose sufficient surface areas for the exudation of gas. Further in this known practice no attempt is made to upset the unstable equilibrium of the gas.

A considerable part of the gas exuded by coal when pressure is released and it is exposed to the air exists in the coal as free gas, whether laid down as such within the coal or later absorbed by it from outside sources or formed within the coal by chemical processes. Gas may also exist in the coal in solution in which case it is condensed within the intra-molecular space of the solid. Gas may also be adsorbed by the coal in which case a condensation of gas (sometimes perhaps in liquid state) appears around the infinitesimal surfaces of the solid substance. Or gas may be found absorbed in water lying within the coal or other porous bed.

Before pressure is released part of this free gas lies in the fissures extending through the coal, but a much greater part is absorbed within or adsorbed by the coal itself. The gas contained in the pores of the coal often of molecular size is often under pressures sometimes as high as several thousand pounds per square inch. These minute pores are connected with each other and the system so connected is in a way a network of small capillaries.

The gas existing in the coal under the foregoing conditions is driven off gradually during mining operations, so that it is a continuing hazard to workmen and a handicap to mine ventilation and the loss of it is a waste of a natural resource.

In some coals a quantity of gas is formed by chemical changes after a part

of the pressure on the coal has been released. This formed gas, as well as the originally occluded absorbed gas, in order to escape from the coal, must also pass out through the capillary system to and through the fissures in the coal.

In coals of certain structures, the exudation of gas from the pores and capillaries is at a relatively high rate without stimulation by artificial means. In other structures, I have found that the exudation of the gas from the pores and capillaries of the coal is at a relatively low rate, but that the same may be greatly hastened by slightly raising the temperature of the coal, regardless of the fact that the coal may have a relatively high initial temperature prior to treatment by heat. Likewise an increase in temperature hastens any gas forming chemical action that may be taking place within the coal, thus when the natural exudation of gas from the pores and capillaries is slow an increase in temperature has a doubly beneficial effect. The gas held within the pores and in the capillary system tends to expand and drive itself out of the pores even with a slight increase in temperature over the initial temperature. In some cases an increase of ten degrees Fahrenheit above the initial temperature may be expected to almost double the rate of gas exudation. The application of heat also reduces the viscosity of the gas causing it to flow out more freely.

The invention consists in a process of obtaining naturally occurring gas from coal in situ or from some other carbonaceous deposit containing naturally occurring gas which consists in gaining access to the deposit and subjecting the deposit to a heat treatment appreciably below the temperature at which destructive distillation commences so as to cause this gas to be exuded or to flow into the pore spaces or passages in the deposit from which the gas may be recovered.

The invention also consists in the further features hereinafter described and claimed.

In the accompanying drawings,

Figure 1 is a diagrammatic plan illustrating a system of tunnelling whereby the invention may be carried into effect, and

Figure 2 is a similar view illustrating an alternative system.

When it is intended to remove the gas from coal areas, which exude gas at a relatively high rate, I drive a tunnel 3 into, or adjacent to the coal seam comprising the area from which the gas is to be removed, leaving sufficient coal or rock pillars for support of the roof. This tunnel during the course of construction may, if necessary be ventilated by any usual means, such as a brattice and blower.

Having constructed the tunnel of any desired length, I then extend from the tunnel, into the coal area from which the gas is to be removed, sapping tunnels 4 which may be from two hundred and fifty to two thousand feet or more in length, depending upon the area from which gas is to be removed and which may be of a size capable of use as haulage ways, when mining operations are to be commenced after the removal of the gas. The first sapping tunnel of the system should be located a sufficient distance from the old workings 2 to prevent the infiltration of air therefrom into the gas removal system. In particularly gaseous areas, it may be found advantageous to temporarily seal the sapping drifts at their entrance into the tunnel to prevent loss of gas and simplify the ventilation of the tunnel.

It may be found desirable in certain instances, to increase the exposed surface of the coal from which gas is to be removed by making borings from the sapping tunnels into the coal seam, and in some instances, particularly where subsequent mining of the coal is not intended, to place explosive charges in the bore holes and to shoot them for the purpose of breaking up the coal seams and exposing larger surfaces. Ordinarily it is better practice to shoot the explosive charges after the completion of the gas removal system, but prior to completing sealing same.

Having completed the sapping tunnels 4 and such borings therefrom as may be desirable, I then construct, preferably of concrete poured under pressure, one or more barriers 5 in the open-end of the tunnel 3 nearest the old workings of the mine or the shaft 1 as the case may be. A pipe 6 is extended from the shaft or from the old workings through the barriers into the tunnel and is connected through a suitable pipe 7 to exhaust pumps and gas reservoirs located either in the mine, or on the surface of the ground.

I have found that the installation of barriers of concrete and other substantially impervious material is not always sufficient to prevent the infiltration of air around the barriers when a partial vacuum is placed on the gas removal system. In cases where the coal seam consists of a relatively impervious mass, the infiltration of air around the barriers

may be prevented by coating the surface of the coal in the tunnel between the barriers with a plastic, such as asphalt paint, also by extending the plastic coating along the surface of the coal at the end of the tunnel connected with the shaft or old workings of the mine and in some cases along the face of the coal in the old workings nearest to the sapping or gas removal system.

However, in some instances it will be found that a coating of a plastic such as asphalt paint will not be sufficient to prevent the infiltration of air. In such instances, I propose to use two or more barriers at the end of the tunnel and to fill the tunnel between the barriers with a mixture of mud and crude oil or some other plastic material and in some cases to maintain it under pressure. Upon placing the gas removal system under a vacuum, the mud or other plastic material will flow into the seams and crevices of the coal face adjacent to the walls of the tunnel and effectively seal the gas removal system against the infiltration of air.

In certain formations, it is advantageous to drive a tunnel below the coal seam from which gas is to be removed and to drive sapping drifts or bore holes from the tunnel into the coal seam from which gas is to be removed. After such gas removal system is completed the sealing operation is as hereinbefore described.

In some instances, it will be found that gas is not only occluded in coal seams, but exists in the pores in the rock roof and floor rock above and below the seams. In such cases it will be necessary to provide means not only for the removal of the occluded gas from the coal seams, but for the removal of the interstitial gas from the roof and floor rock. In such cases I drill bore holes from the sapping tunnels 4 beyond the coal seam into the roof and floor rock adjacent thereto and if the floor and roof rock are not sufficiently porous to permit the relatively easy flow of gas into the bore holes, I place explosive charges therein, and then explode them to cause a fracture in the rock and thus expose additional area for the flow of gas therefrom.

Having completed the gas recovery system as above described, I construct a second tunnel system, consisting of a tunnel 9 with connecting sapping drifts 10, which are located substantially parallel to and between the sapping drifts 4 of the gas recovery system, which second system is then sealed in the manner hereinbefore described, pipes 12, 13 being arranged for connection of the tunnel system with a source of heated gas and means for placing the heated gas under pressure. This second tunnel system may be designated as a warm gas pressure system.

Having completed the gas recovery system and the warm gas pressure system above described, I proceed as follows: Heated natural or manufactured gas is pumped under pressure through the pipes 13, 12 into the tunnel 9 and connecting tunnels 10 of the warm gas pressure system which upsets the unstable equilibrium by which the adsorbed or absorbed gas is held in the coal. This unstable equilibrium may also be upset by the digging of the tunnel and sapping drifts and the exploding of charges to jar the coal and/or cause a sudden and violent increase in pressure within the coal body near the system.

The heated gas is then driven into the fissures exposed at the coal face and passes along these fissures through the coal toward the parallel gas recovery sapping drifts, heating the coal in the area between the adjacent sapping drifts to any desired degree, depending upon the initial temperature and pressure of the gas introduced.

When the temperature of the coal composing the walls of the pressure tunnels and sapping drifts has been increased ten degrees Fahrenheit or more above the initial temperature of the coal and this increased temperature has extended well back into the coal face or tunnel wall, the temperature of the injected gas may be reduced to allow such injected gas to take up the heat of the coal near the walls of the pressure tunnels and carry this heat into the coal nearer the gas recovery tunnel 3 and sapping drifts 4.

While the operations are being carried on the gas recovery system may, if gas is not being produced therein at pressures sufficient to deliver it to storage reservoirs on the surface of the ground, be placed under partial vacuum and the gas exhausted in the manner hereinbefore described.

The exudation and recovery of gas is controlled by the relation between the initial temperature of the coal and the temperature and pressure of the gas injected. The higher the increase in temperature and pressure, the more rapid the extraction.

When the body of the coal under treatment has been sufficiently heated and a sufficient percentage of occluded gas effected, the injection of heated gas

may be discontinued, and if desirable the pressure tunnels 9 and sapping drifts 10 may be converted into a gas recovery system while the coal is still warm, the gas being exhausted through the pipes 12, 13 initially provided for the introduction of heated gas. In this way gas may be withdrawn simultaneously from all sides of the coal body under treatment.

In cases where the coal is quite porous or where other conditions make it desirous I may substitute wells 14, 15 (Figure 2) drilled from the surface of the ground, for one or both of the tunnel systems, sealing the wells from the infiltration of atmospheric air, the same as when tunnel systems are used. In this modification of my process, I inject the warm gas through one system of wells (the wells 14 for example), and recover gas either through a sapping drift system or the other system of wells (15 for example).

When wells for gas extraction or warm gas injection are used, I prefer to drill same from the surface to and through the coal seam, and in some cases to explode explosive charges in the wells opposite the exposed coal face therein to fracture and jar the coal, and upset the unstable equilibrium by which the adsorbed or absorbed gas is held in the coal, to facilitate the extraction or injection of gas, as the case may be.

In the operation of either system, it is desirable to recover the gas from the coal before the coal has time to cool off, as coal absorbs (instead of exudes) some gas, particularly when it is cooling or cold.

If the coal is heated and allowed to cool again without any gas being removed in the meanwhile, the coal when cool will contain its original gas, but if while the coal is warm, substantially all recoverable gas is extracted from it, then when the coal cools again, it will be substantially non-gaseous in subsequent mining operations.

From the above description, it is believed that those skilled in the art will clearly understand the present invention, and it is manifest that changes may be made in the details disclosed without departing from the spirit of the invention, as expressed in the claims.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Process of obtaining naturally occurring gas from coal in situ or from some other carbonaceous deposit containing naturally occurring gas which consists in gaining access to the deposit and subjecting the deposit to a heat treatment appreciably below the temperature at which destructive distillation commences so as to cause this gas to be exuded or to flow into the pore spaces or passages in the deposit from which the gas may be recovered.

2. Process according Claim 1 which consists in applying pressure to the deposit.

3. Process according to Claim 1 wherein heating of the deposit is achieved by supplying thereto heated gas under pressure.

4. Process according to Claim 1, 2 or 3 wherein a partial vacuum is applied to facilitate removal of the gas.

5. Process according to any of the preceding claims which consists in gaining access to the coal or other gaseous deposit through horizontal underground tunnels or through a vertical well system or both.

6. Process according to Claim 5 wherein the tunnels and/or wells are sealed against the infiltration of air.

7. Process according to Claim 5 or 6 comprising boring branch tunnels from a working tunnel and from the adjacent branch tunnels boring further tunnels into the area between the branch tunnels.

8. Process according to Claim 7 wherein said further tunnels are disposed in spaced and parallel relationship.

9. Process according to Claim 7 or 8 which comprises sealing the ends of the branch tunnels adjacent the working tunnel against the infiltration of air.

10. Process according to Claim 7, 8 or 9 which comprises supplying heated gas to one of the branch tunnels and collecting the exuded gas in the adjacent branch tunnel.

11. Process according to Claim 10 which comprises applying a partial vacuum to the gas collecting branch tunnel.

12. Process according to Claim 5 which comprises supplying heated gas to a system of wells and recovering the exuded gas through another system.

13. Process according to Claim 5 or 12 which comprises exploding a charge in the wells opposite the coal or other gas bearing face exposed thereby.

14. The process of obtaining gas from coal or other gaseous deposit in situ substantially as described with reference to the drawings.

Dated this 17th day of September, 1934.

MARKS & CLERK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.

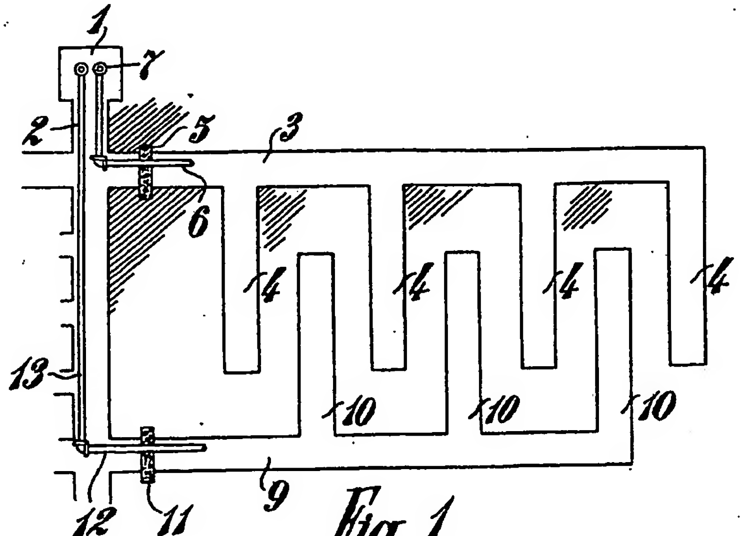

Fig. 1.

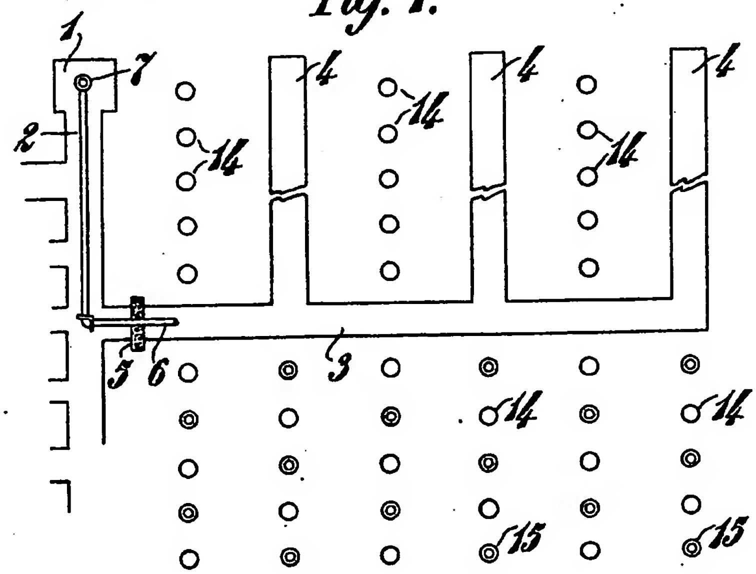

Fig. 2.